# NASA, California Partner to Help Address Drought, Improve Water Management

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Workshop on Remote Sensing Applications for Water Resources Management and Drought

February 25th, 2014

# Airborne Snow Observatory

## Knowing the mountain snowpack for water resources and snow science

Thomas H. Painter, JPL/Caltech

NASA

Jet Propulsion Laboratory
California Institute of Technology

Western Water Assessment

McGurk Hydrologic

NSIDC
National Snow and Ice Data Center

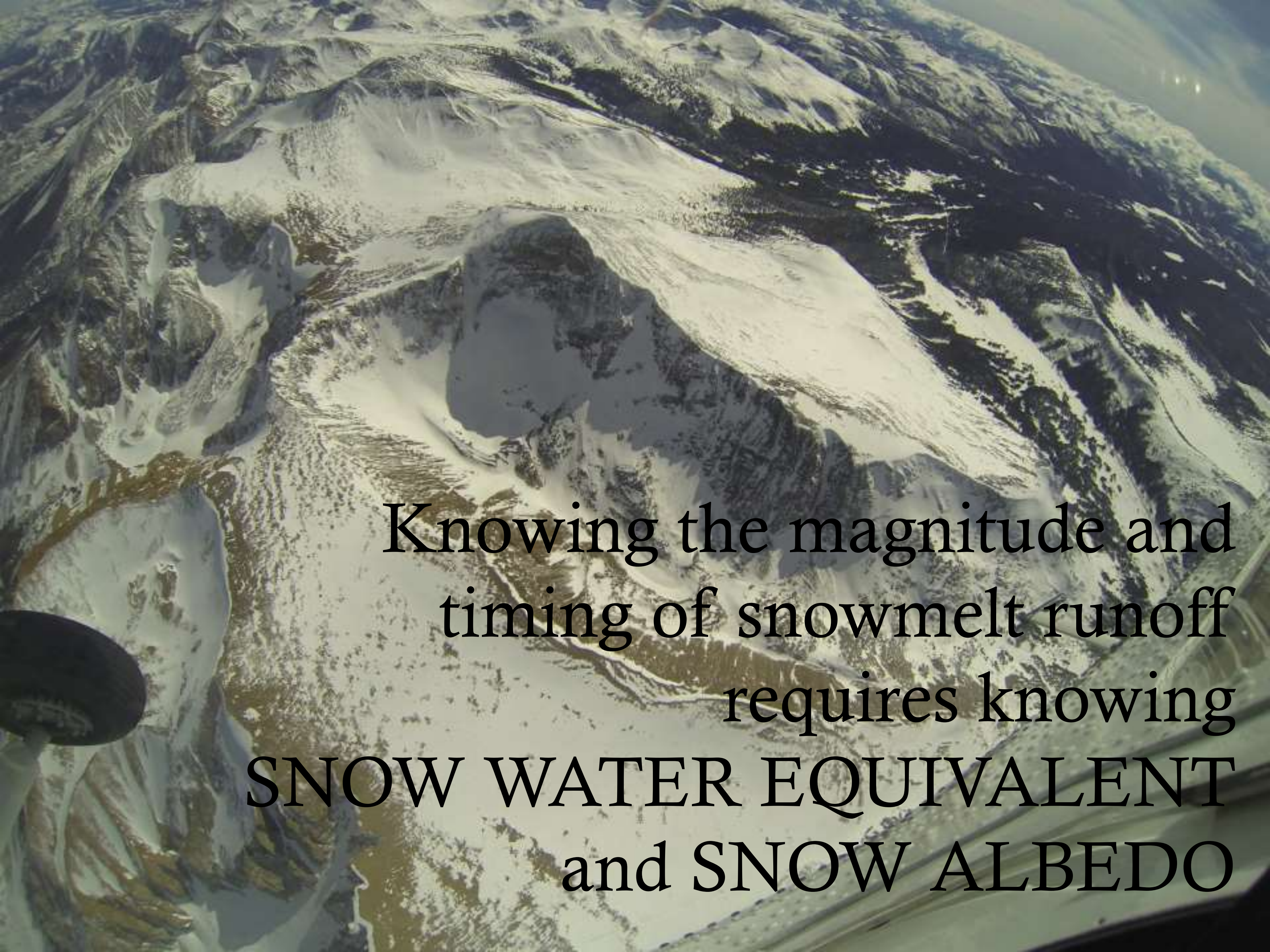
# Water from Snow

About 75% of the Western US freshwater supply comes from snowmelt.

Reservoirs in California hold about a year and a half of annual runoff, making for strong sensitivity to interannual variability in snowfall

The definition of optimization of reservoir storage, hydroelectric generation, achievement of environmental metrics depends on the timing and magnitude of runoff and varies from basin to basin

Snowmelt modeling and forecasting is migrating to physically based models, ultimately demanding markedly better snow information

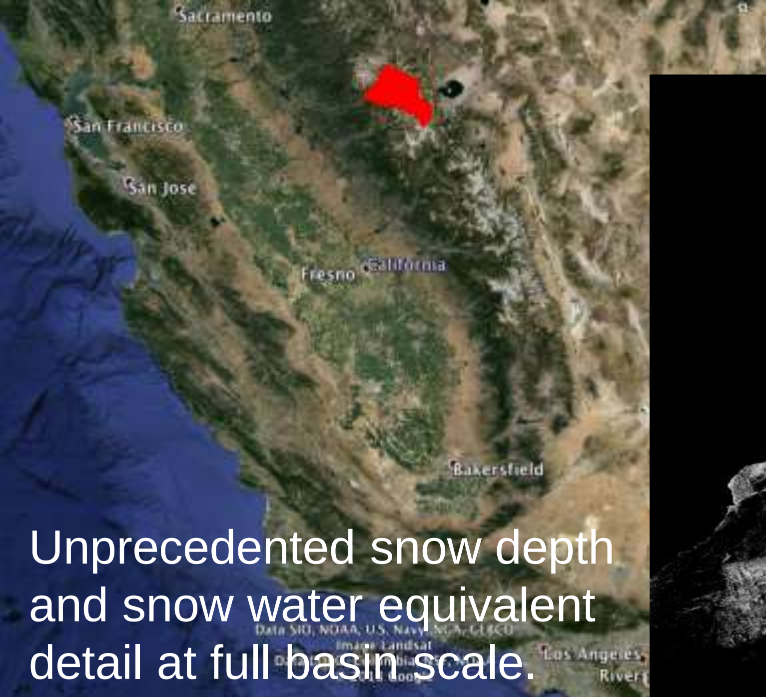

Knowing the magnitude and
timing of snowmelt runoff
requires knowing
SNOW WATER EQUIVALENT
and SNOW ALBEDO

# This is how we have known SNOW WATER EQUIVALENT

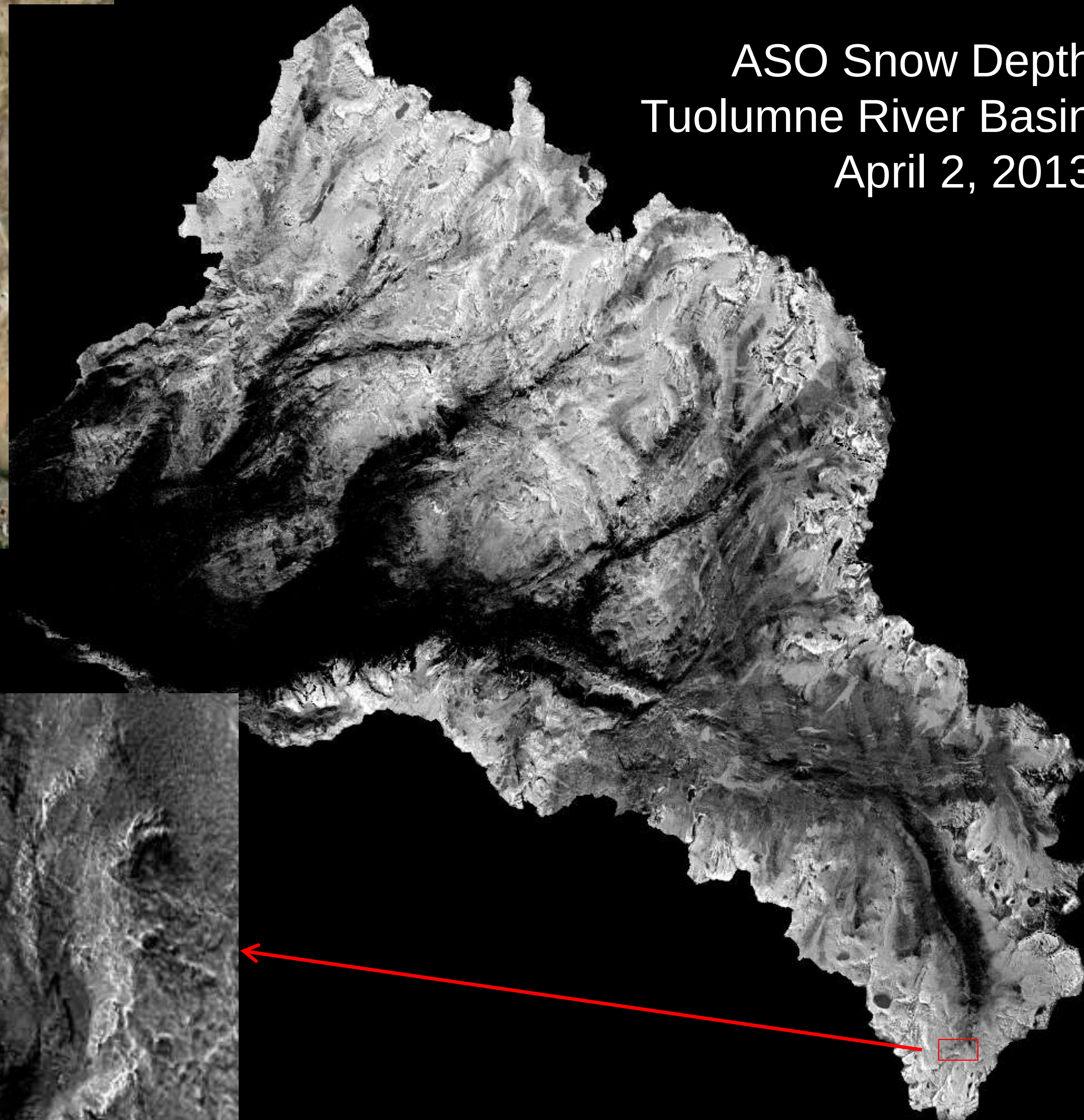

The way we want to see it/

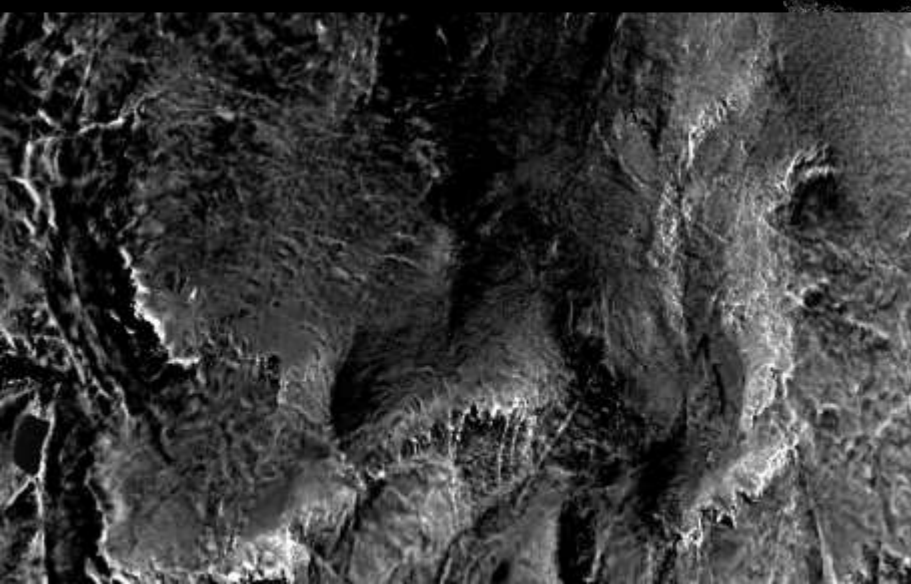

Imaging Spectrometer
0.35-1.05 µm
2 m spatial resolution from 4000 AGL
Albedo
3D Scanning LiDAR
1064 nm
1 m spatial resolution
Snow Water
Equivalent

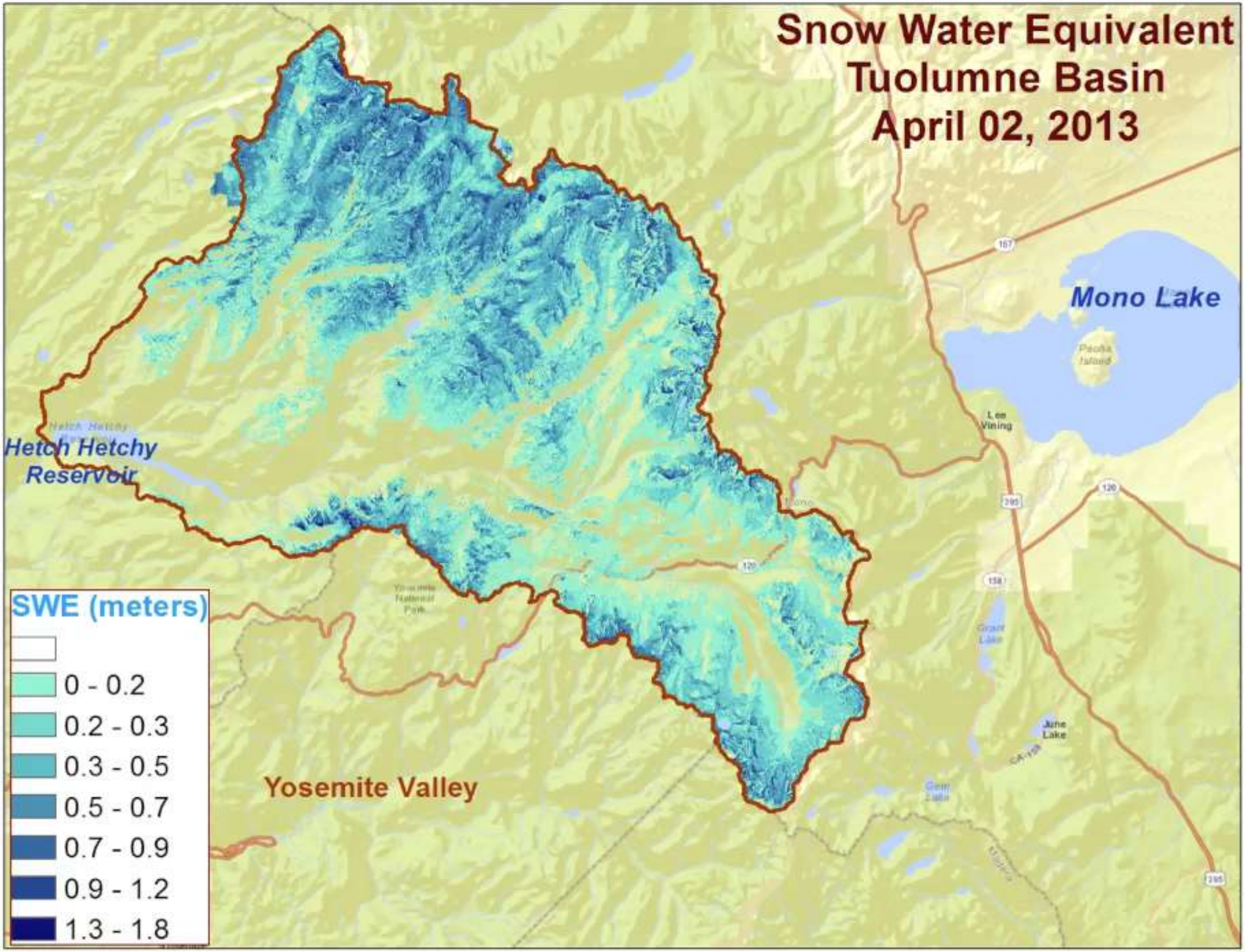
ASO Snow Depth
Tuolumne River Basin
April 2, 2013




Unprecedented snow depth and snow water equivalent detail at full basin scale.

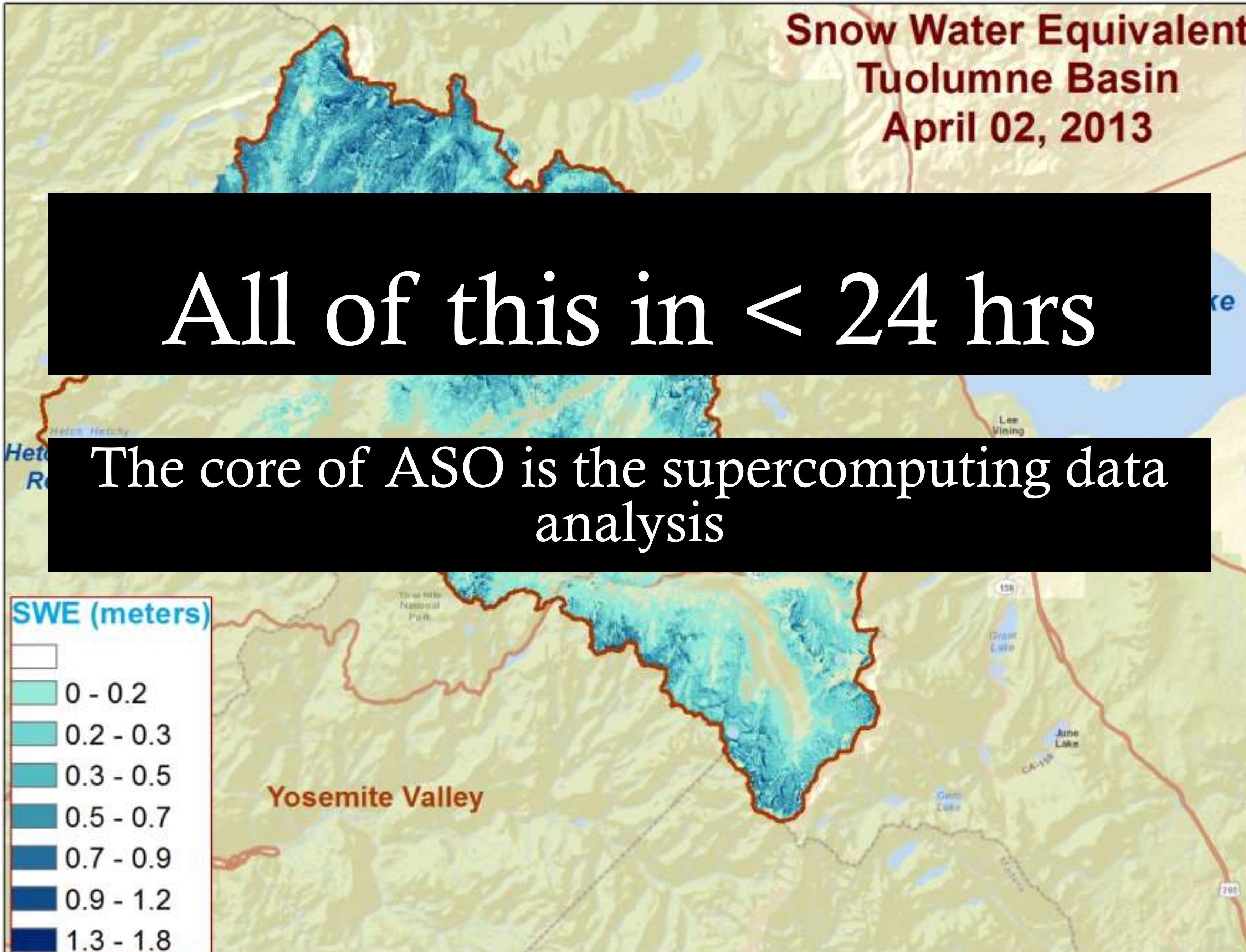




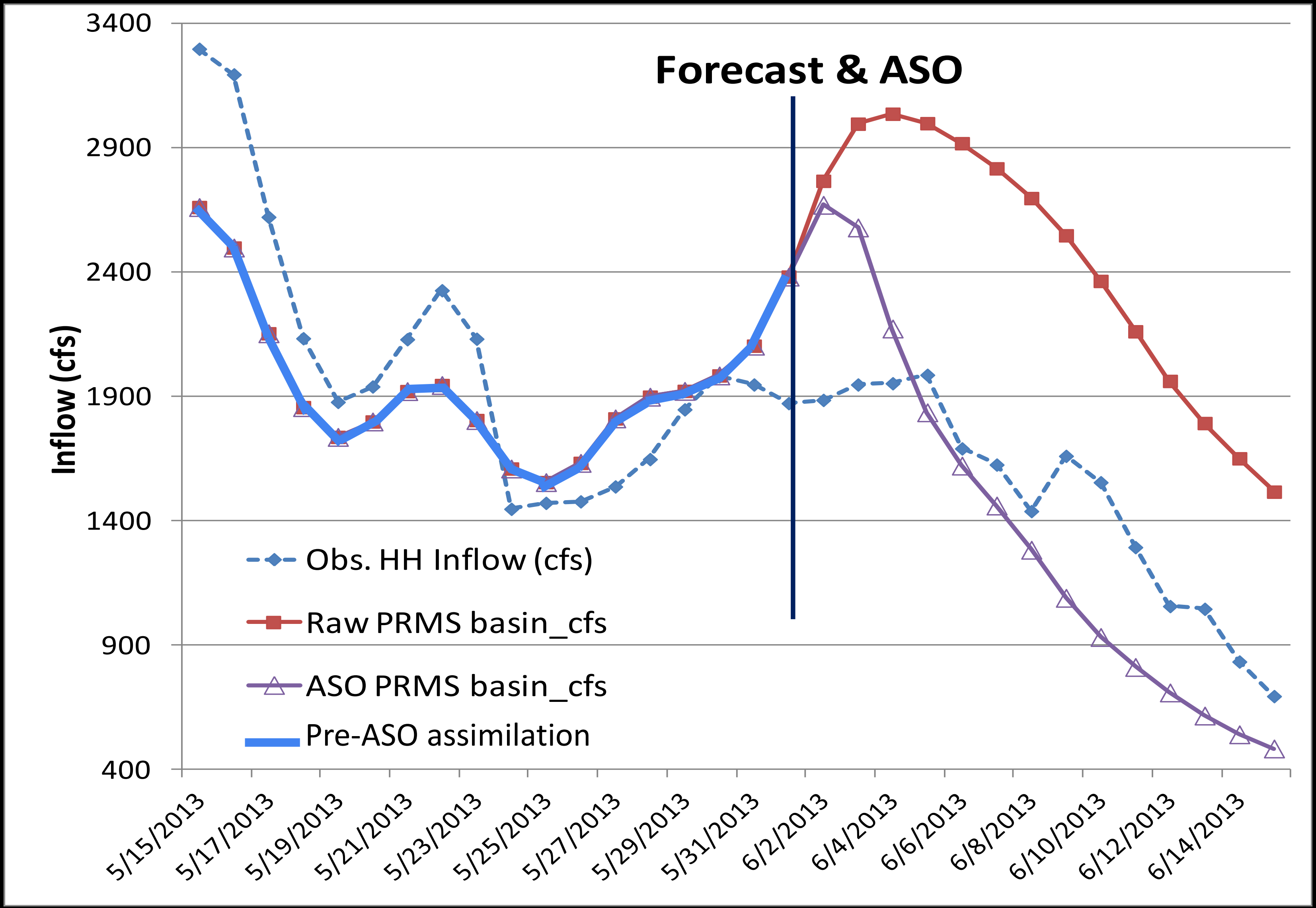

Snow Water Equivalent
Tuolumne Basin
April 02, 2013
Mono Lake
Hetch Hetchy
Reservoir
Yosemite Valley
SWE (meters)
0 - 0.2
0.2 - 0.3
0.3 - 0.5
0.5 - 0.7
0.7 - 0.9
0.9 - 1.2
1.3 - 1.8

# All of this in < 24 hrs

The core of ASO is the supercomputing data analysis



# ASO Results and Reservoir Fill



# Fallowed Area Mapping for Drought Impact Reporting and Decision Making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***James Verdin (PI), Prasad Thenkabail, and John Dwyer, USGS***
***Rick Mueller and Audra Zakzeski, USDA NASS***
***Forrest Melton, Lee Johnson, Carolyn Rosevelt, NASA ARC-CREST / CSU Monterey Bay***
***Jeanine Jones, California Department of Water Resources***
***Rama Nemani, NASA Ames Research Center***


Media Package for

WORKSHOP ON REMOTE SENSING APPLICATIONS FOR
WATER RESOURCES MANAGEMENT AND DROUGHT

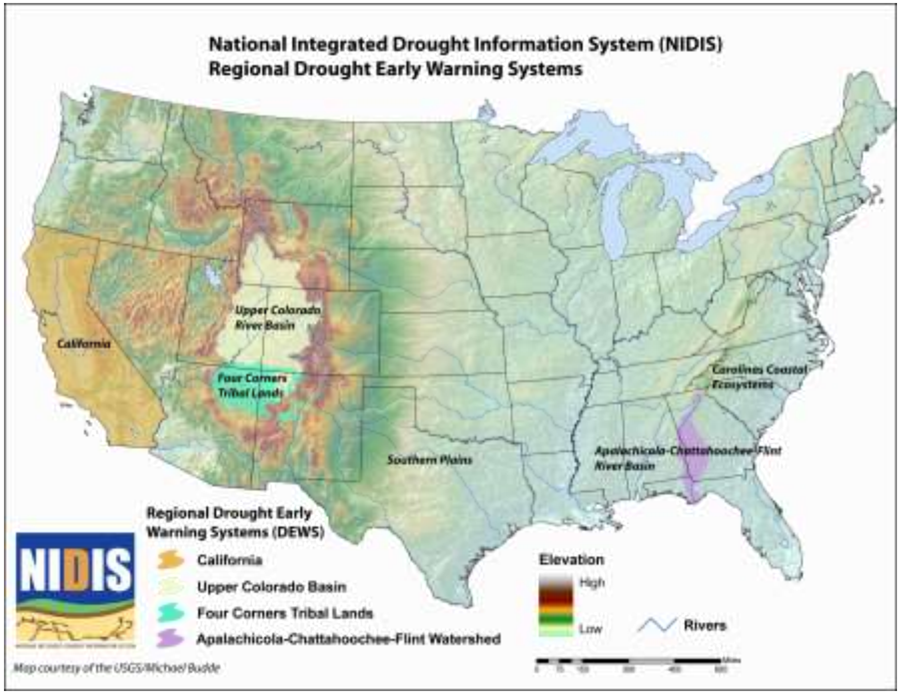
February 25-26, 2014

# Drought Impacts on Land Fallowing

- Unprecedented reductions in 2014 water allocations from the Central Valley Project and State Water Project, both north and south of the Delta
- Increase in extent of fallowed acreage expected because farmers are unable to fully irrigate their crops
- Timely and accurate information on fallowed acreage can support drought response

# Drought Impacts on Land Fallowing

- **Background:** Mapping of fallowed areas during drought identified as a priority for NIDIS by CA Department of Water Resources (CDWR)
- **Information needed:** Product similar to 'idle lands' class in USDA Cropland Data Layer for California, but on a monthly basis during growing season
- **Objective:** Apply satellite data to provide information that will allow CDWR and other stakeholders to identify extent of, or change from historical conditions in, fallowed acreage due to water shortage



# USGS and NASA Satellite Data

Landsat 7 and Landsat 8

30m / 0.25 acres
Overpass every 8 days

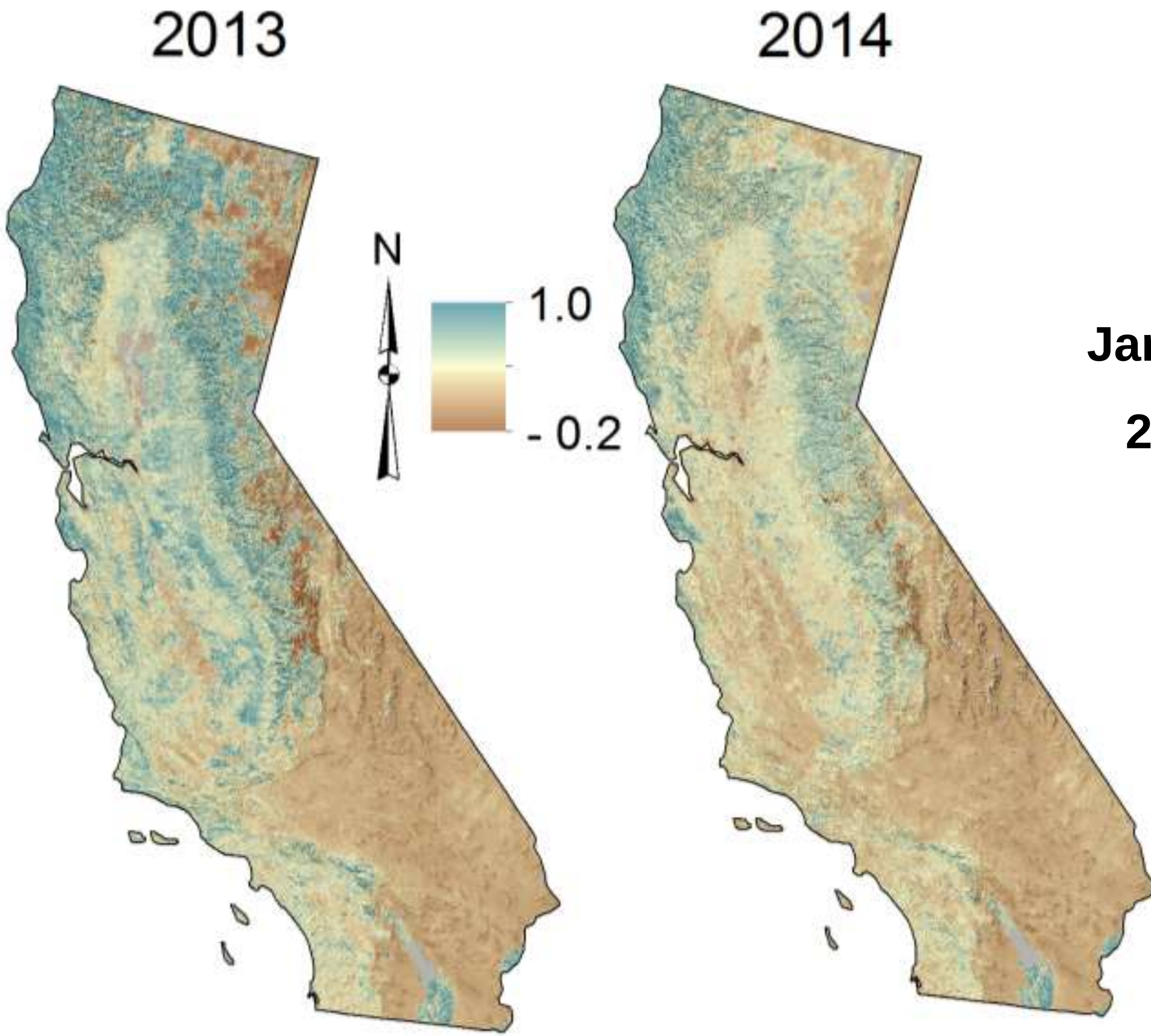
Terra and Aqua

250m / 15.5 acres
Daily overpass

# Statewide Vegetation Condition

January

2013

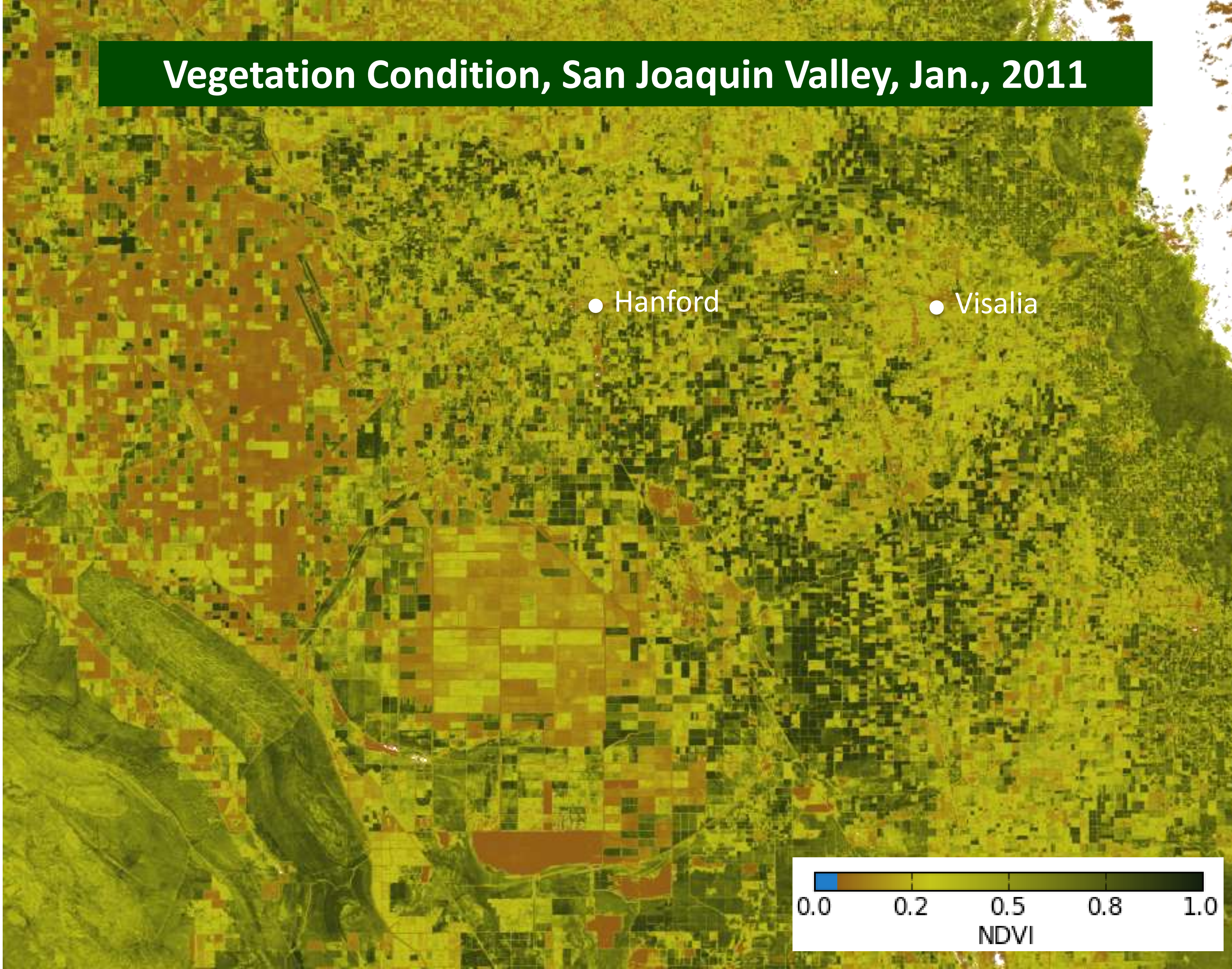



January

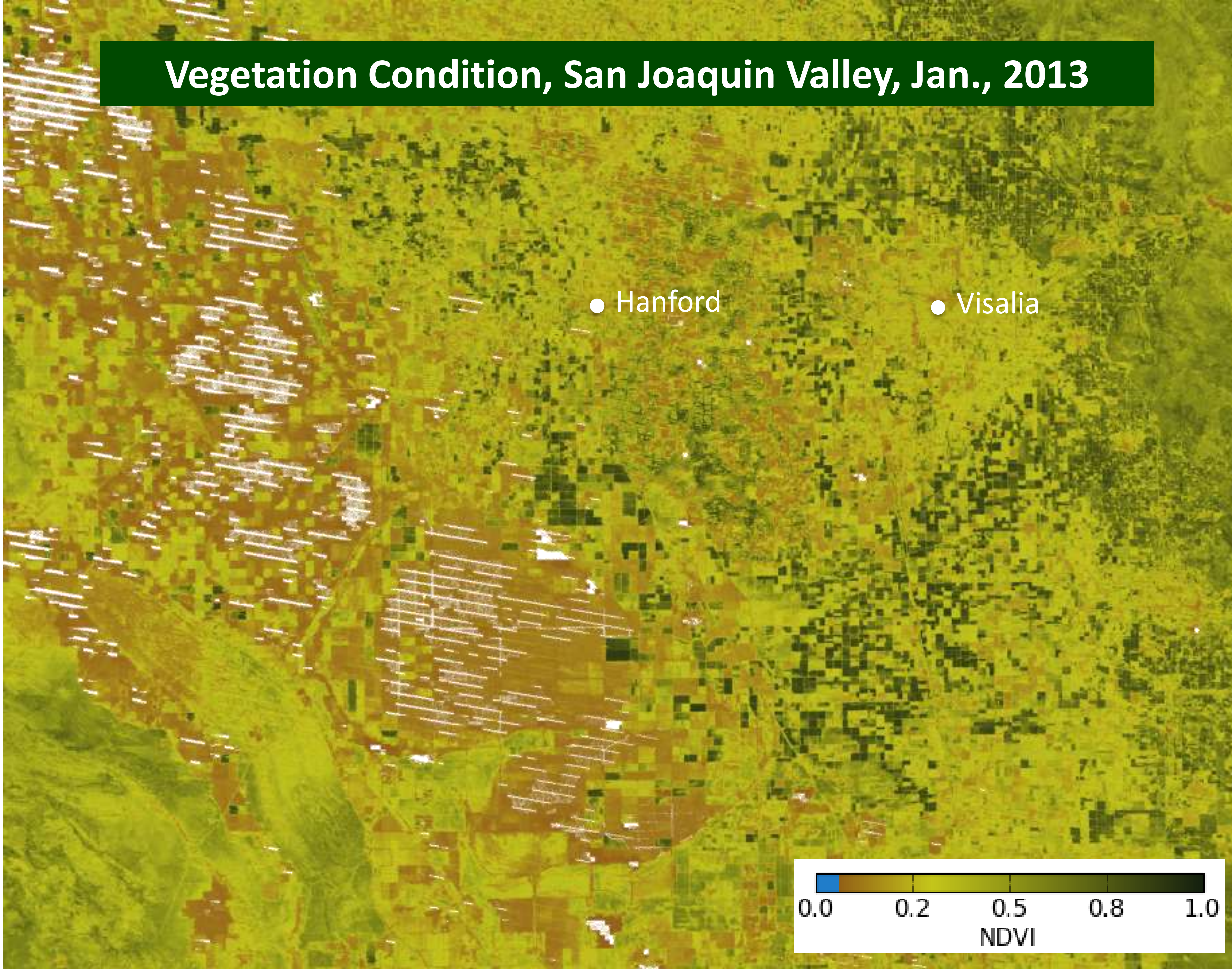
2014

ENHANCED VEGETATION INDEX

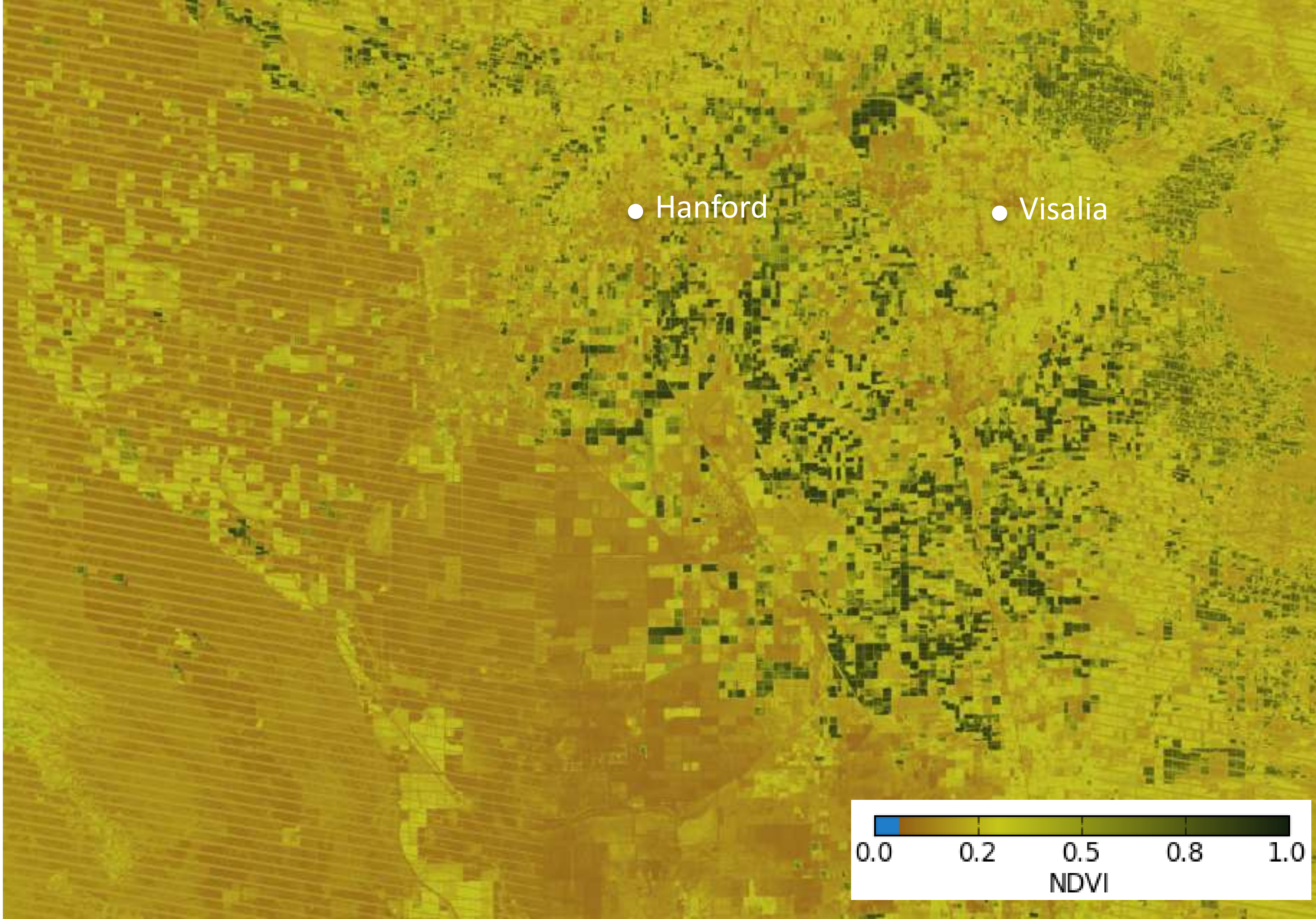
# Vegetation Condition, San Joaquin Valley, Jan., 2011



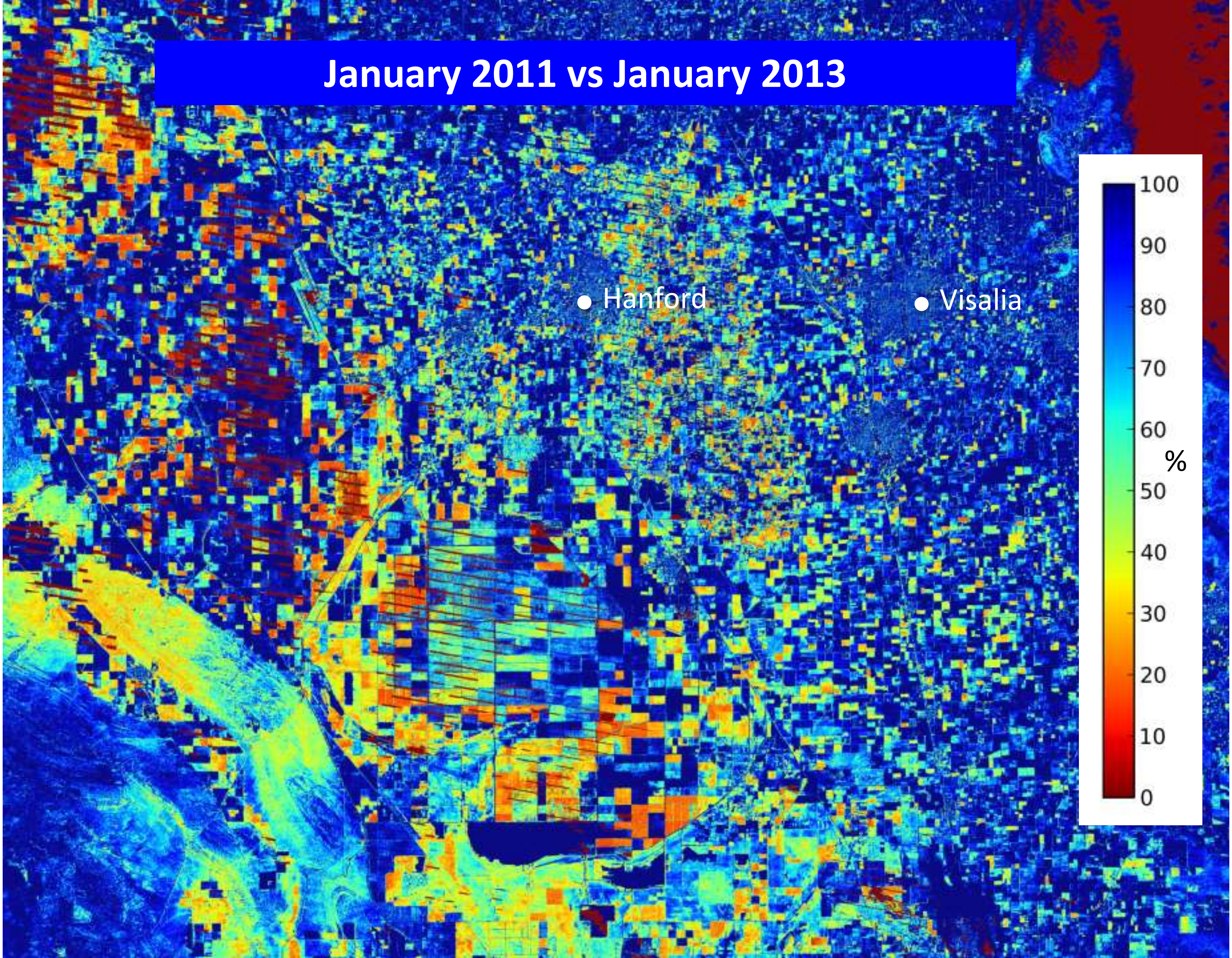
# Vegetation Condition, San Joaquin Valley, Jan., 2013



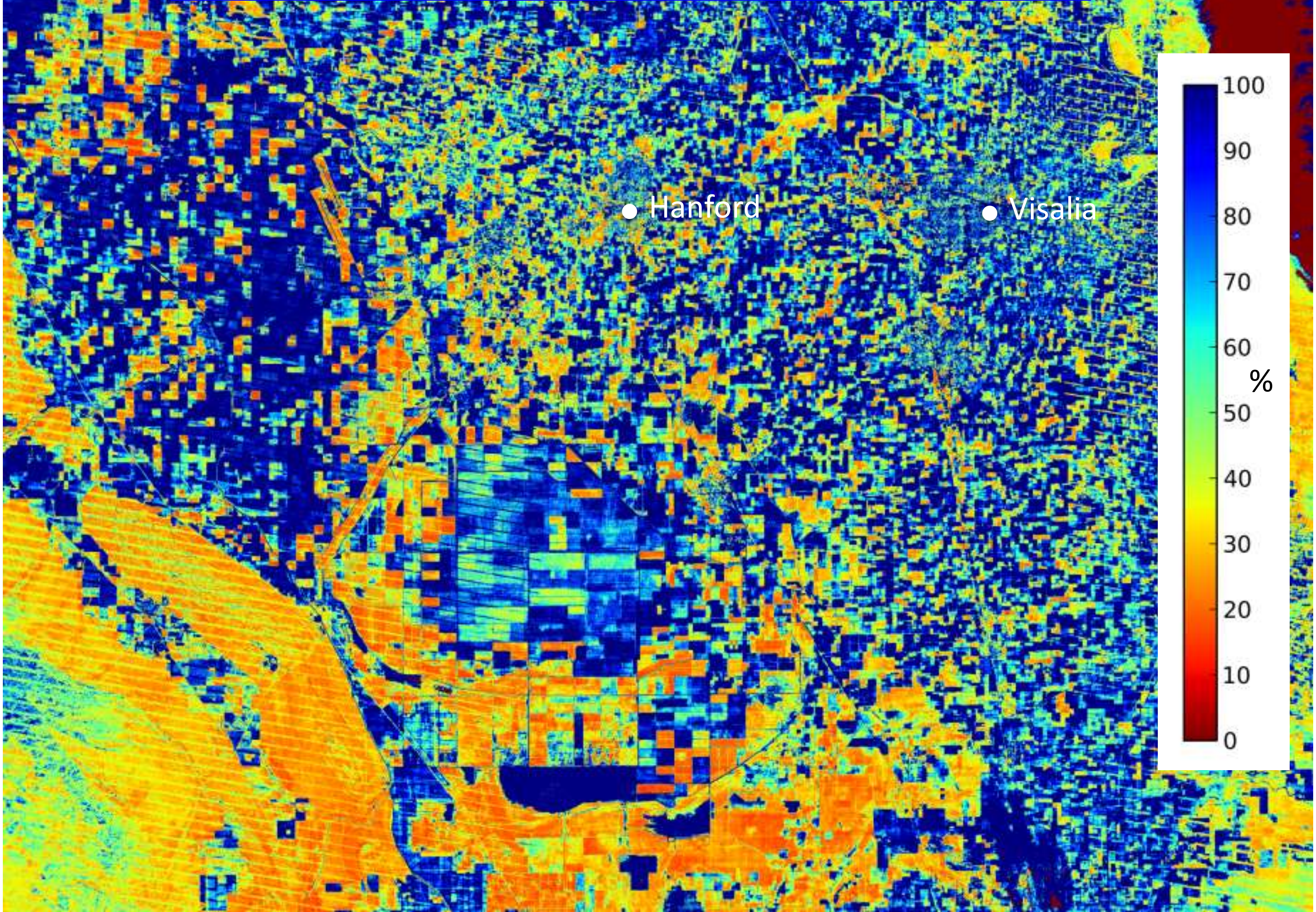
# Vegetation Condition, San Joaquin Valley, Jan., 2014



# January 2011 vs January 2013

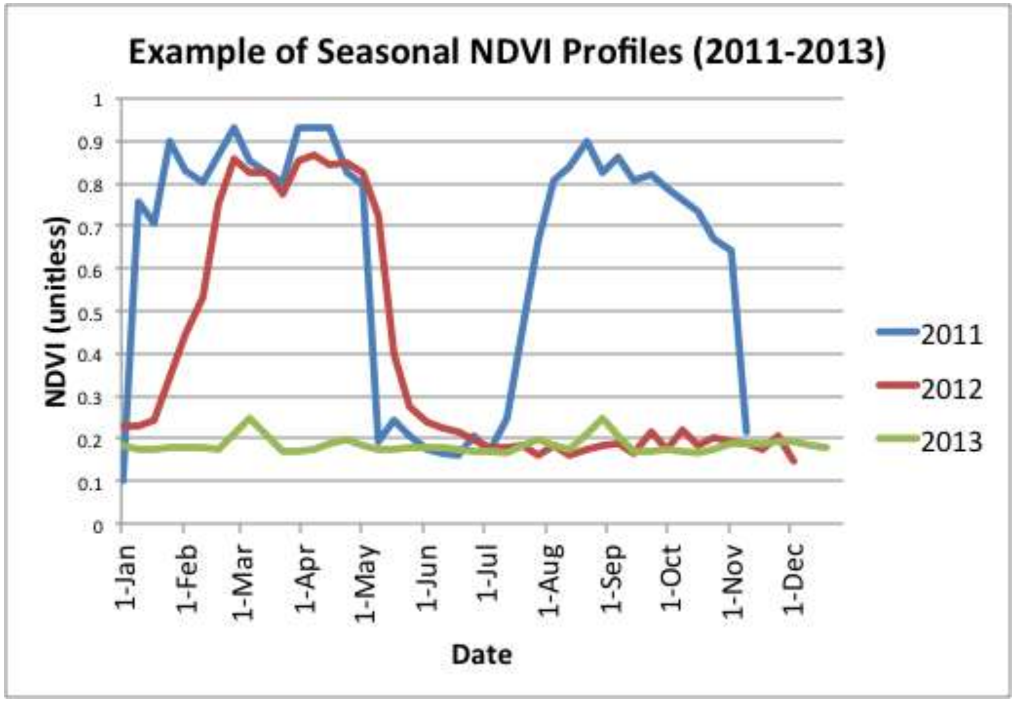


# January 2011 vs January 2014



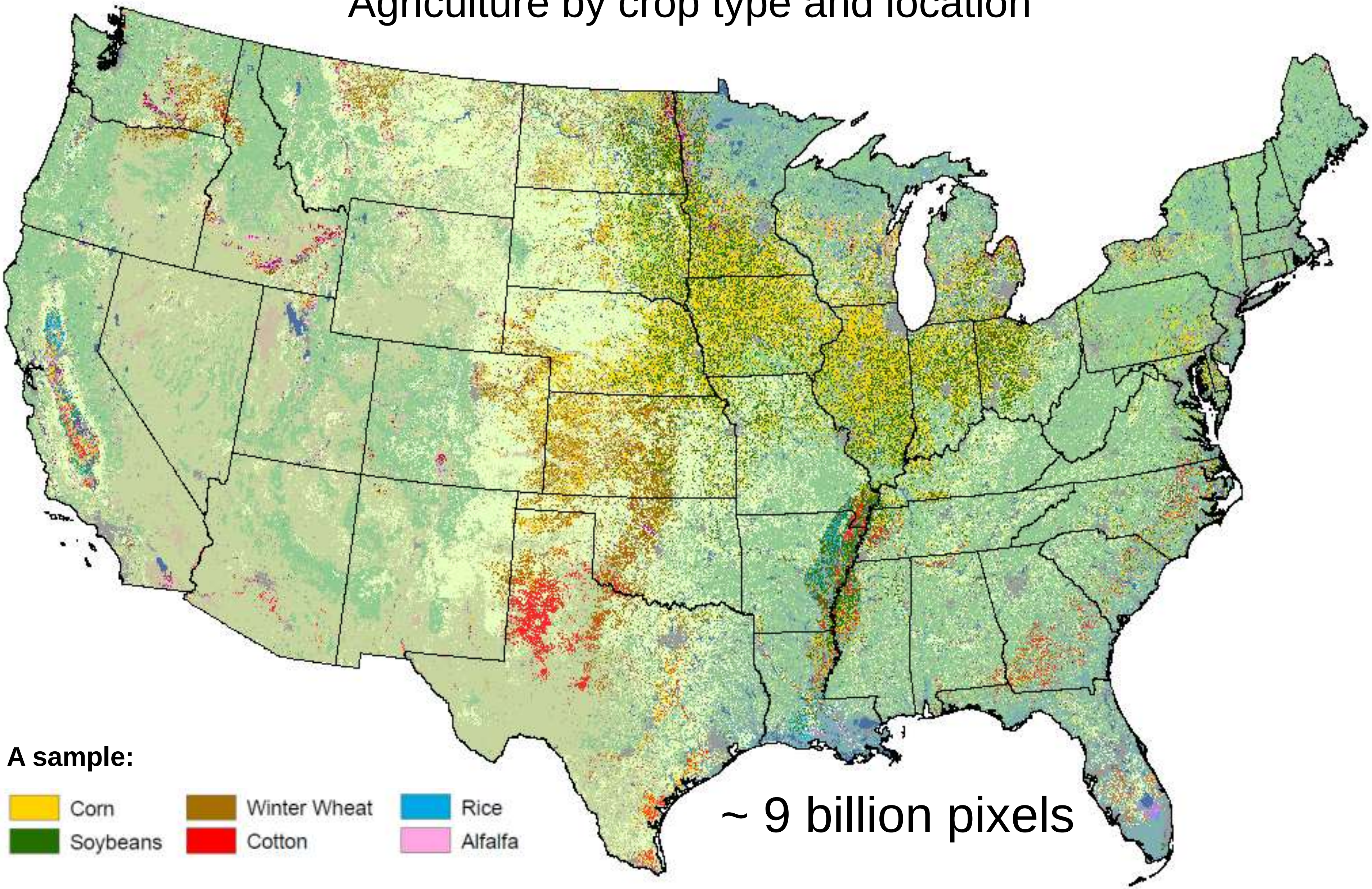
# Early Season Mapping of Fallowed Area (March – June)

- Idling of land results in detectable change in seasonal NDVI profiles



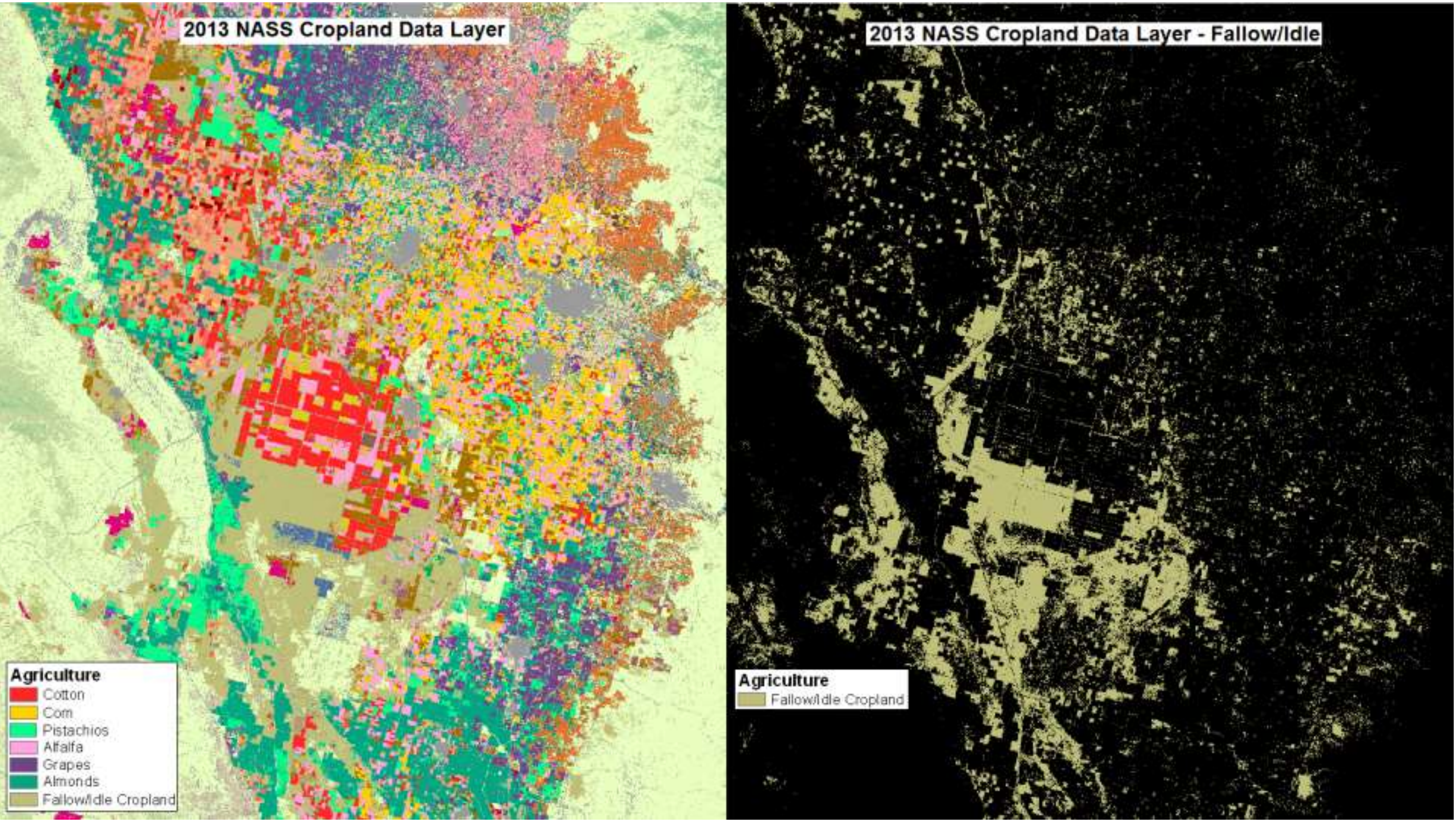

# USDA NASS Cropland Data Layer

Agriculture by crop type and location



# The Fallow/Idle Mask created from CDL

## Binary mask of Fallow/Idle classified pixels




**Idle mask generated during summer/fall growing season**

June – August – September – October

# Project Status

- **Within-season estimates of fallowed acreage for June, August, September, October from USDA National Agricultural Statistics Service using Cropland Data Layer infrastructure**
  - USDA Farm Service Agency (FSA) data used in training decision tree algorithms for each year
- **Early-season estimates for March – May developed by NASA Ames Research Center / California State University Monterey Bay**
  - Decision tree algorithms applied to time-series of satellite vegetation index data
- **Project team will begin producing fallowed area data and maps for California to support CDWR in April 2014**

# Groundswell: Monitoring Groundwater Remotely With Space-Based Radar

Tom G Farr

NASA Jet Propulsion Laboratory,

Pasadena, Calif.

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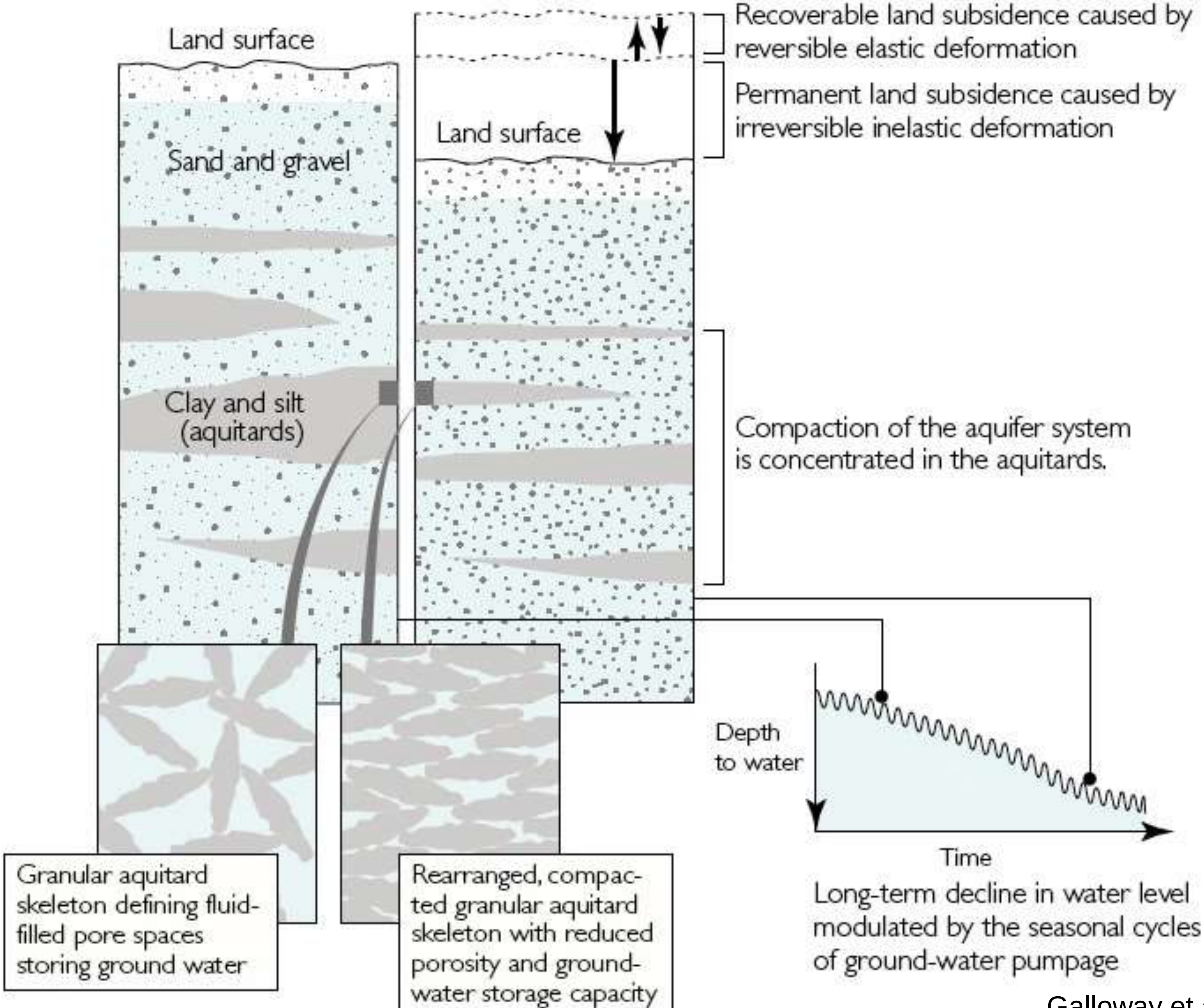
# Monitoring Groundwater from Space

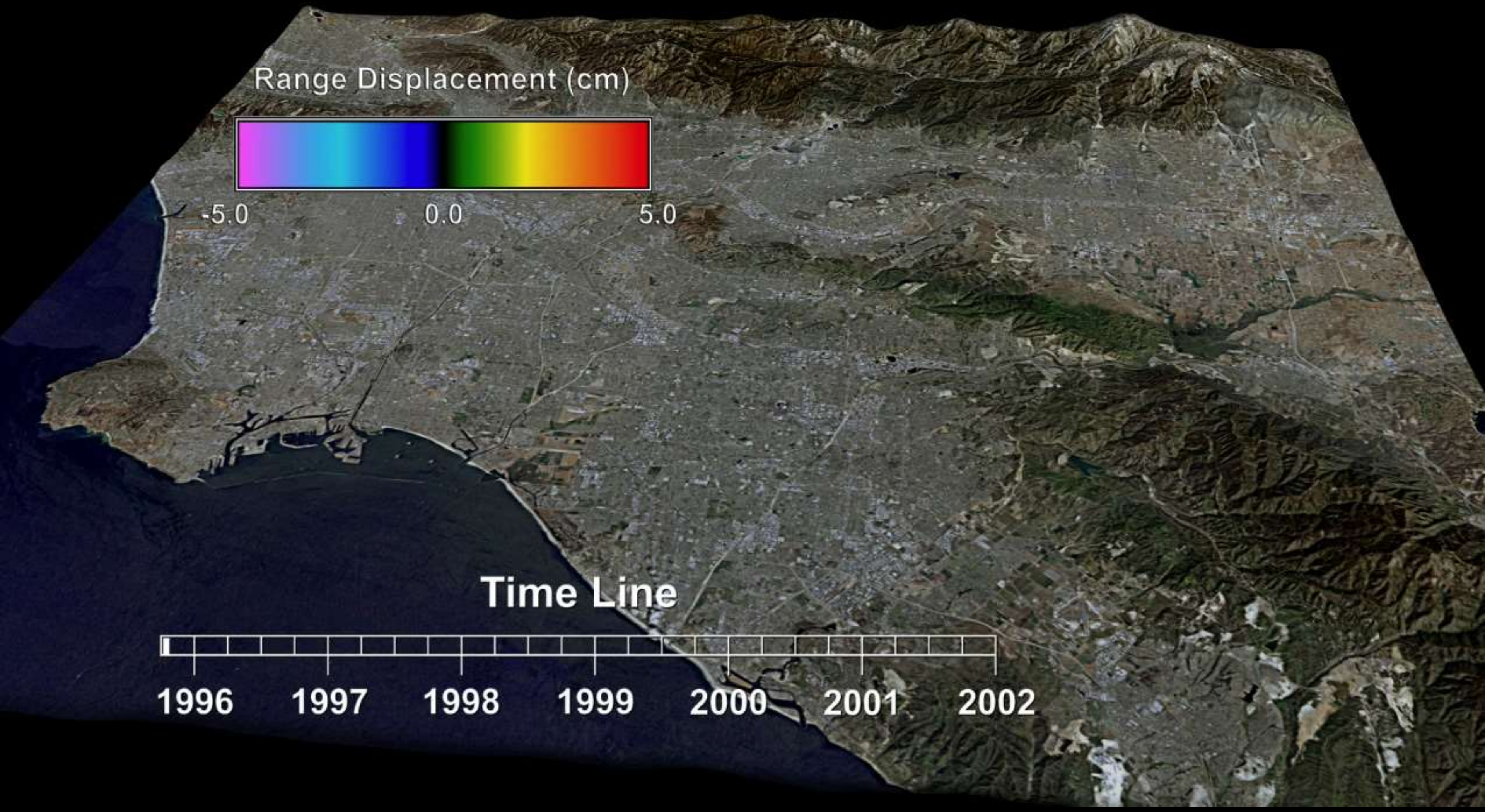
- Groundwater is becoming an increasingly important element in water resource management
- Knowledge of groundwater levels is not uniformly available
- Wells provide some monitoring capability, but there are political and practical difficulties
- Interferometric Synthetic Aperture Radar (InSAR) can provide information on groundwater levels by measuring surface deformation caused by the withdrawal and recharge of aquifers
- The deformation also causes problems for infrastructure, such as aqueducts and trains
- NASA is developing information products for water managers, the public and hydrologists, including animations, maps of 'hot spots,' pixel histories and regional maps of groundwater change

# Hydrology 101: Aquifer Compaction



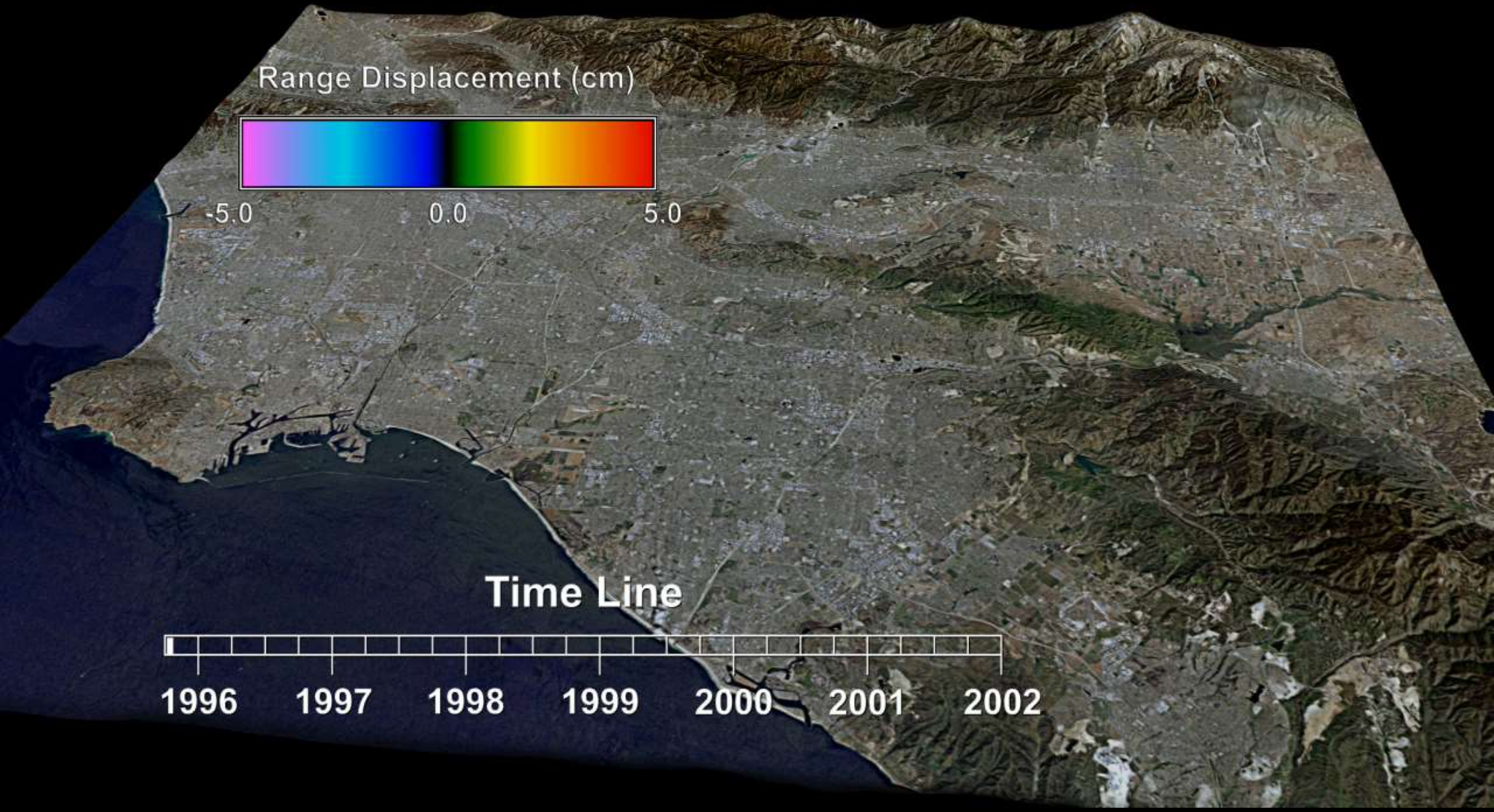

Galloway et al., 1999

# Monitoring the L.A. Basin

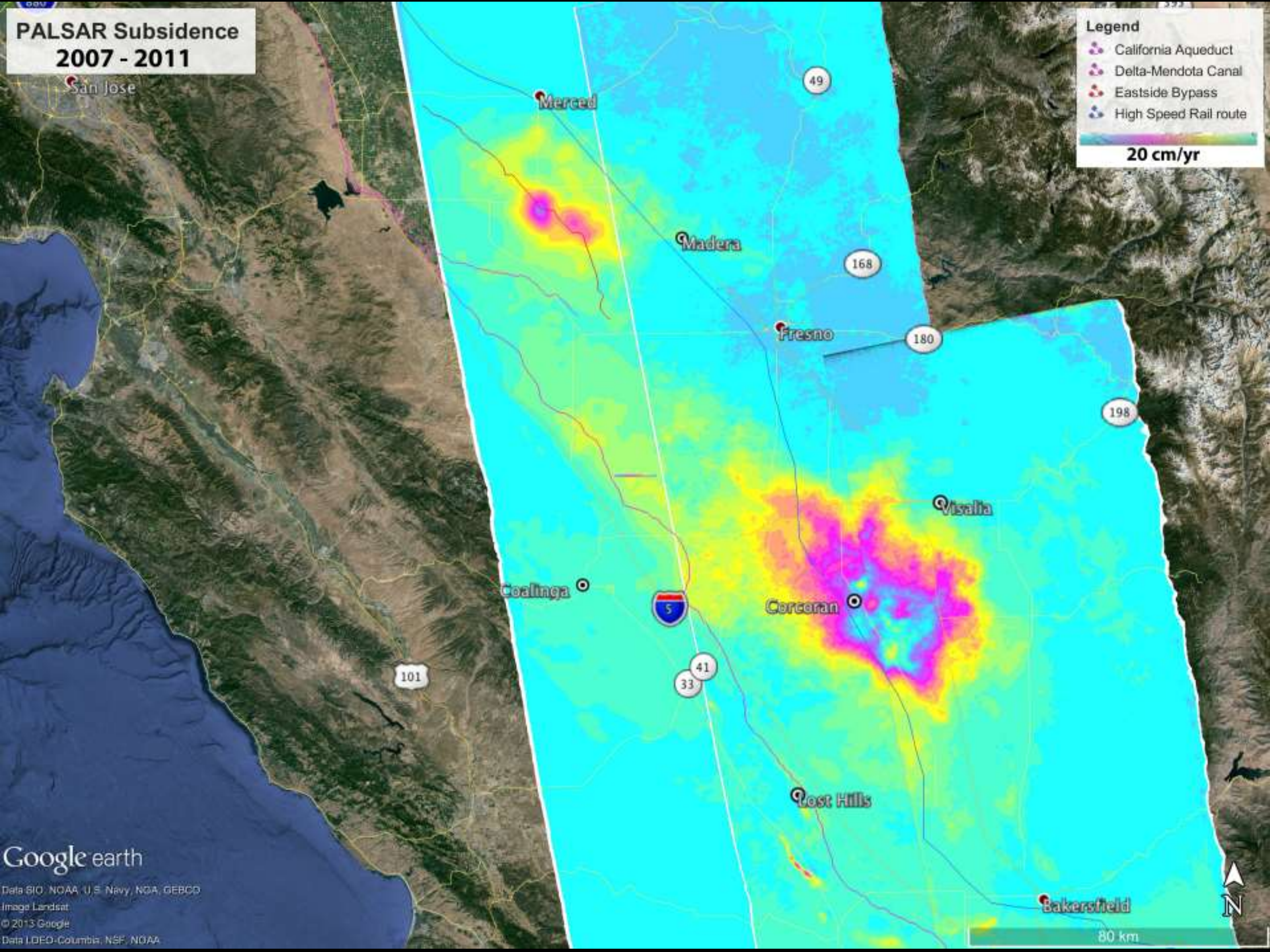



Paul Lundgren, Vince Realmuto, JPL

# Monitoring the L.A. Basin




Paul Lundgren, Vince Realmuto, JPL


PALSAR Subsidence
2007 - 2011
Legend
California Aqueduct
Delta-Mendota Canal
Eastside Bypass
High Speed Rail route
20 cm/yr
San Jose
Merced
Madera
Fresno
Visalia
Coalinga
Corcoran
Lost Hills
Bakersfield
49
168
180
198
5
41
33
101
Google earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat
© 2013 Google
Data LDEO-Columbia, NSF, NOAA
N
80 km

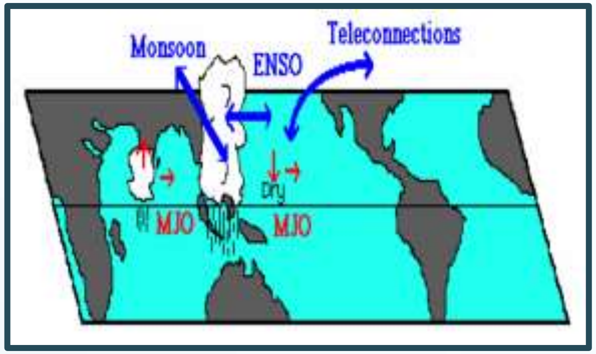
# Subsidence in the Central Valley of California: PALSAR, 2007-2011

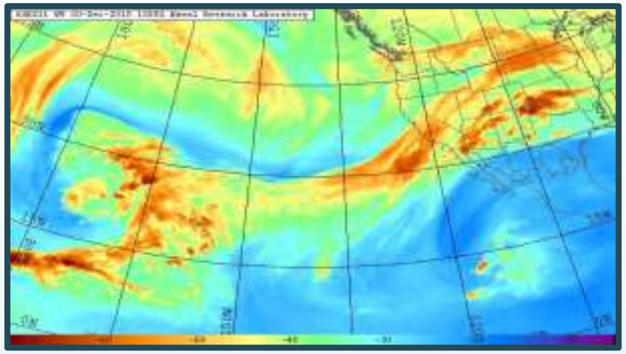
Zhen Liu, Vince Realmuto, Tom Farr, JPL

Jet Propulsion Laboratory
California Institute of Technology

# Atmospheric Rivers (ARs) & the Madden-Julian Oscillation (MJO): Key Phenomena for Predicting California Water Availability and Extremes


Duane Waliser
NASA Jet Propulsion Laboratory
Pasadena, Calif.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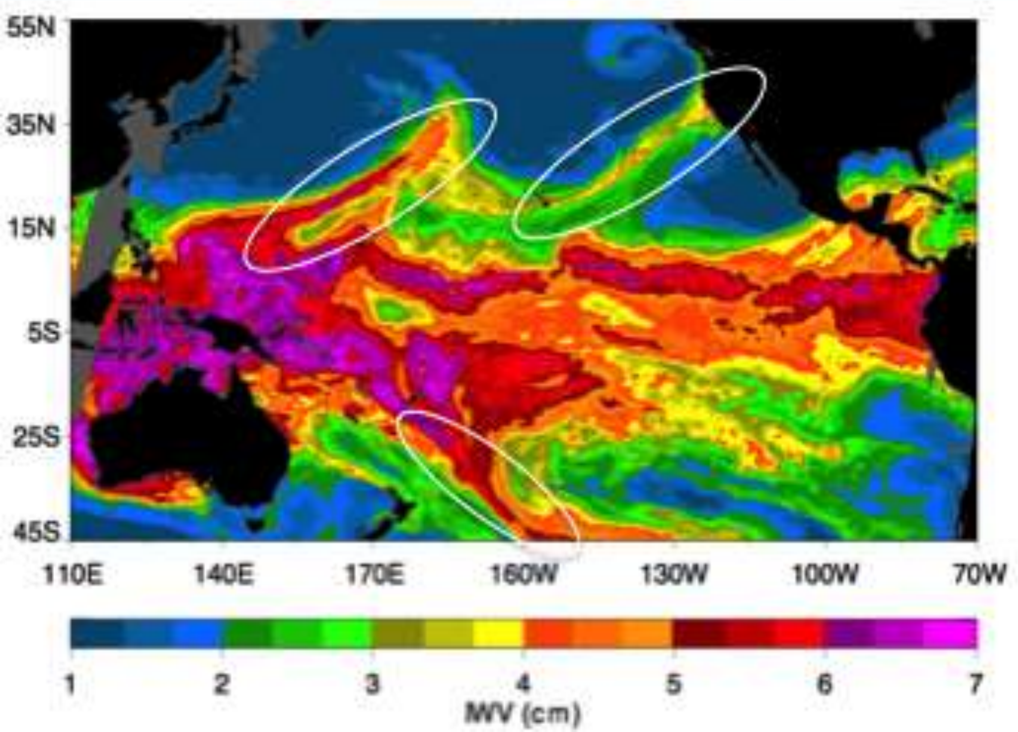
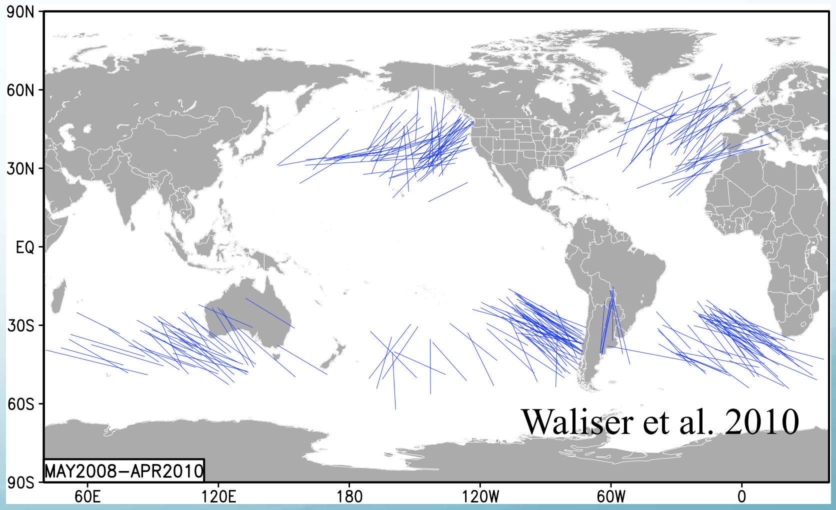
# Rivers in the Sky: Key Characteristics of ARs



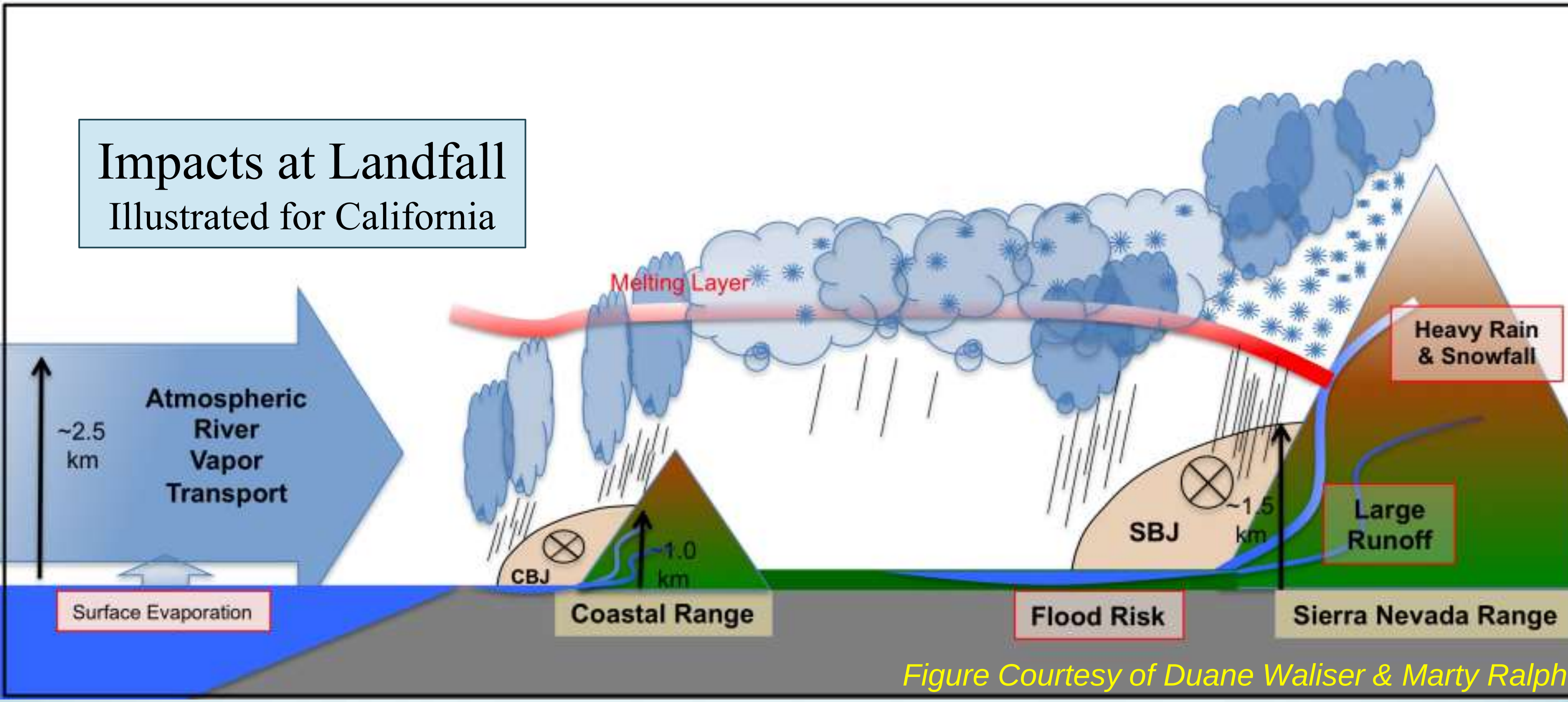

Satellite Measurements of (Total Column) Water Vapor Highlight Streams of Moisture that Transport Water Vapor Poleward & Westward: "Atmospheric Rivers"

Occur Globally
Impact West Coasts of Continents
Role in Weather, Water & Hazards




ARs transport as much as 5-10 times the flow of the Mississippi River

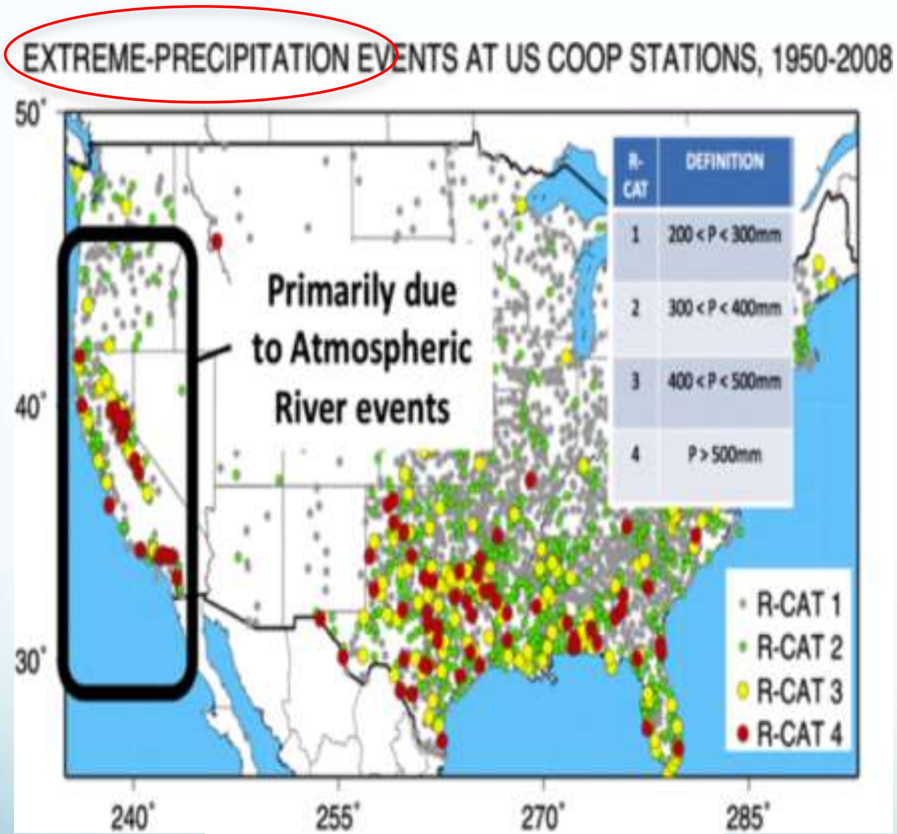
# When Atmospheric Rivers Make Landfall Extreme Precipitation Occurs Near Mountains



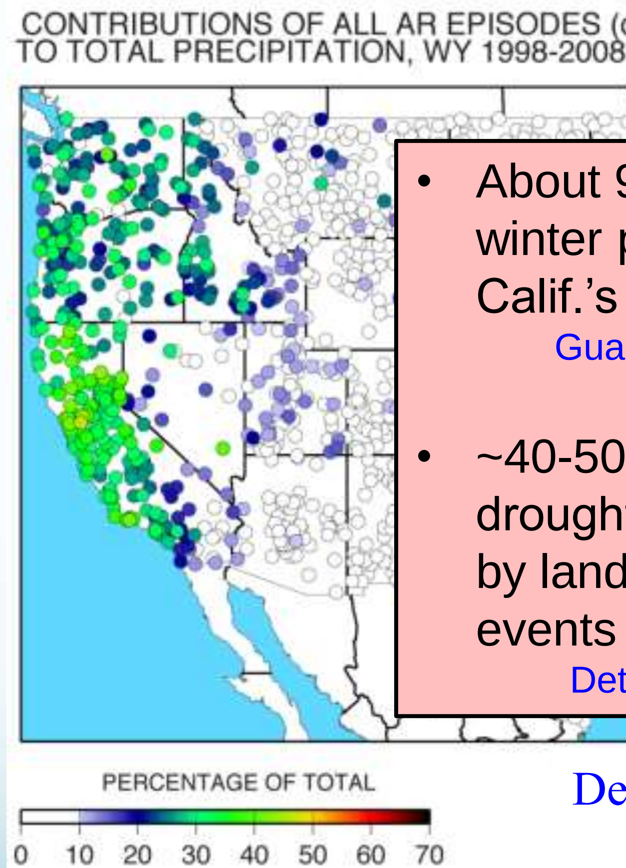

Most flooding / peak streamflow in U.S. coastal states is associated with ARs (e.g. Ralph et al. 2006; Neimen et al. 2011)

# Atmospheric Rivers are to the West What Hurricane Hazards are to the Southeast

# Atmospheric Rivers account for 30-40% of the freshwater supply in the West



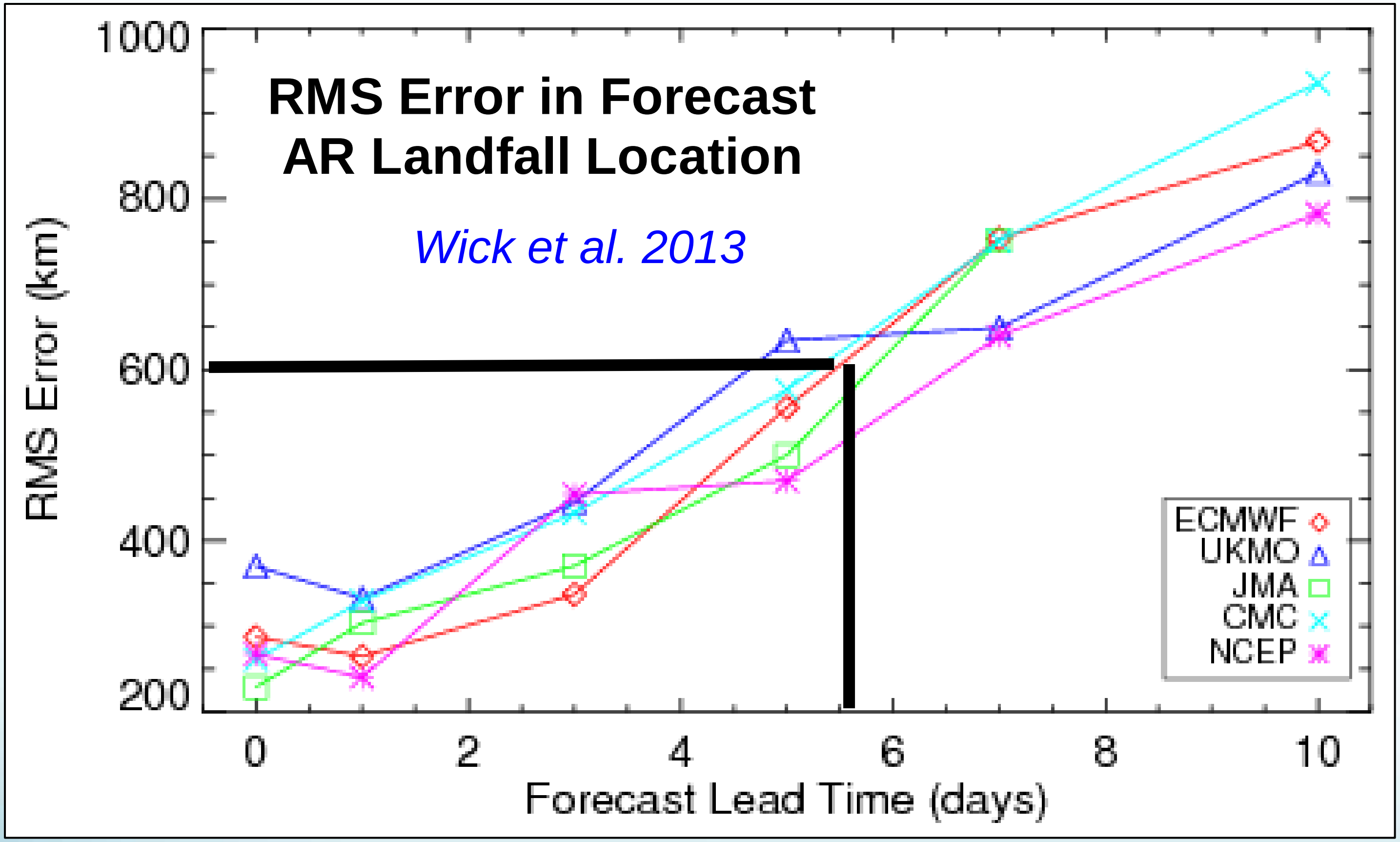

Ralph & Dettinger, 2012




- About 9 AR days per winter provide ~40% of Calif.'s snowpack
  Guan et al. 2013
- ~40-50% of Calif. droughts are "busted" by landfalling AR events
  Dettinger 2013

Dettinger et al. 2011

# Forecasts of Timing and Location of AR Landfall Needs to Improve




For example: at 5-6 day lead time, global weather forecasts cannot determine if AR will hit L.A. or San Francisco

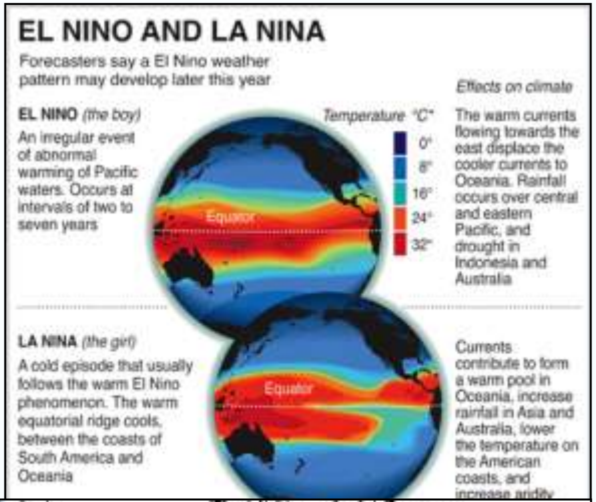
NASA/JPL is teaming with DWR, UCSD, and other agencies/colleagues to carry out **airborne field campaigns, satellite studies, and analysis of weather/climate models** in a steadfast effort to improve our forecasts of atmospheric rivers.

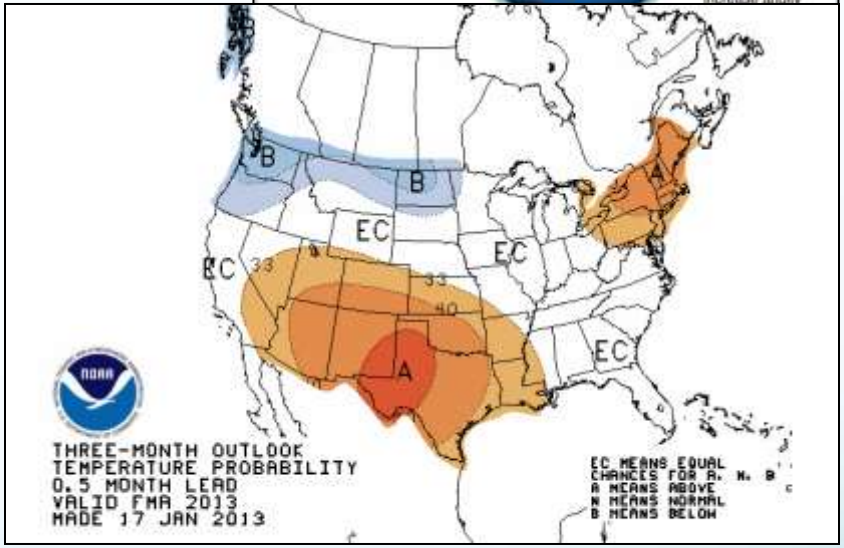
# A Forecast Gap


AR Event

Weather Forecasts ~ O (10 Days)

*(Mid-Latitude Baroclinic Instability & Cyclone Lifetime)*




Seasonal Forecasts ~ O (100 Days)

*(ENSO Phenomena & Local/Remote Circulation Impacts)*

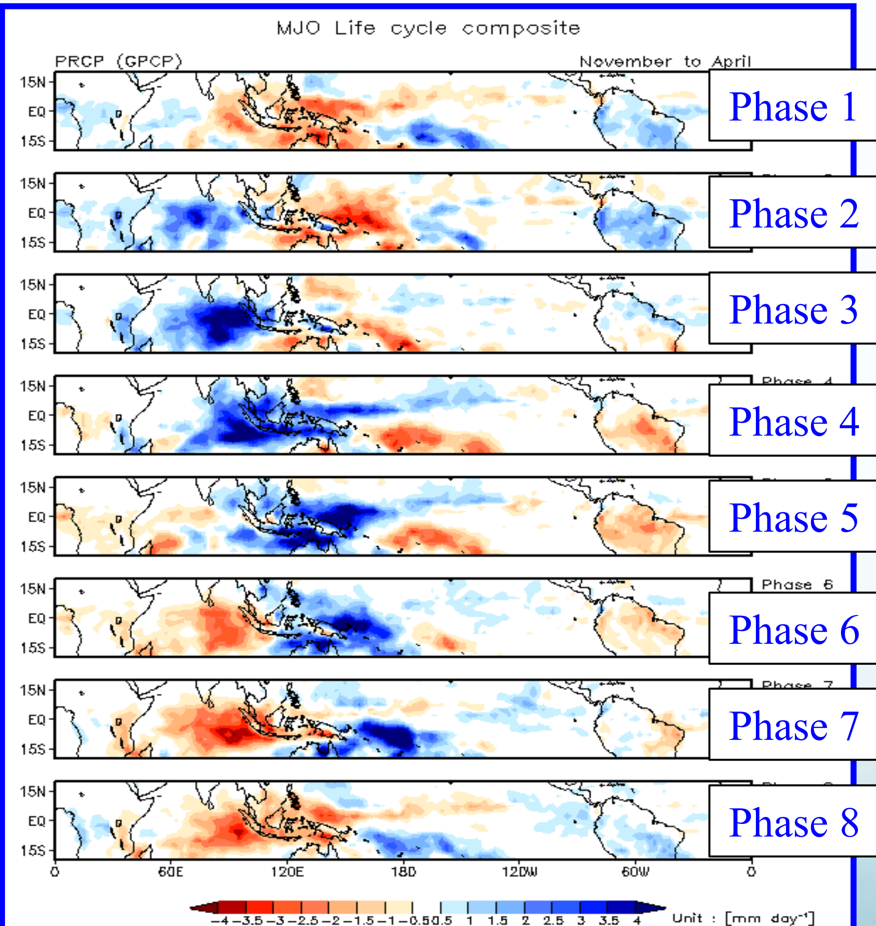
What about forecast information between "weather" and "climate"? Newly, emerging opportunities from the so-called "MJO"

The dominant “subseasonal” variation of the atmosphere – provides unique long-lead prediction potential!

# Madden-Julian Oscillation (MJO)

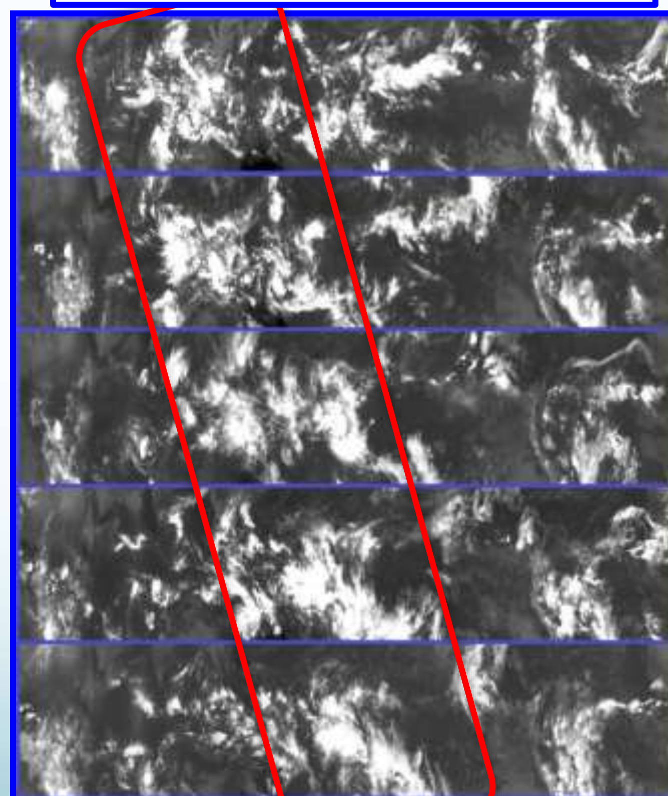
Discovered by Madden & Julian, 1972

## Average MJO Life Cycle ~50 Days



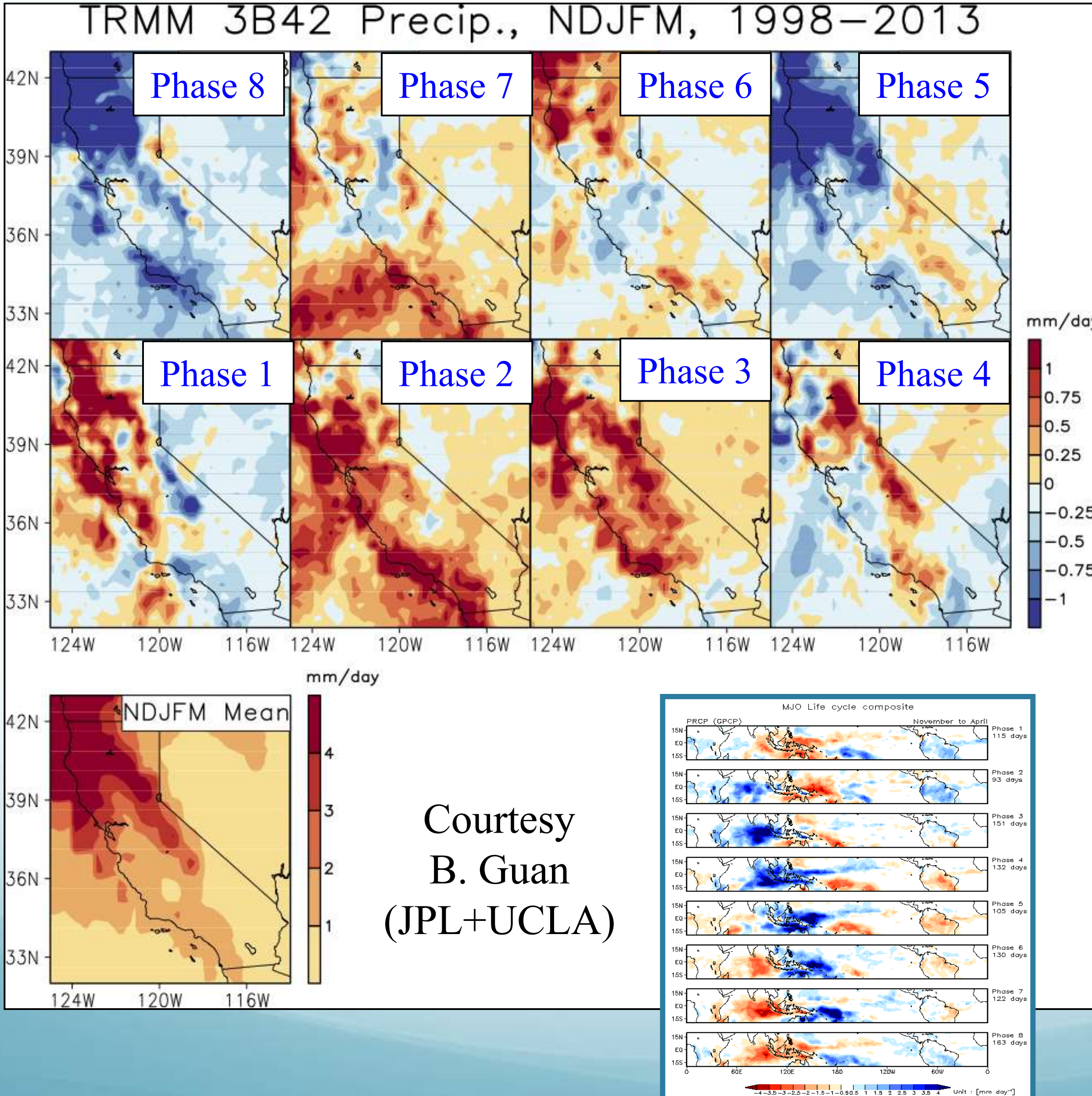

Precipitation anomalies -5 to +5 mm/day

## Actual MJO Event in 1987



B&W “Photo” of whole tropics every 6 days

# The Madden-Julian Oscillation & Calif. Winter Precipitation




Courtesy
B. Guan
(JPL+UCLA)

The MJO systematically influences precipitation over Calif.

Forecast models are now demonstrating MJO forecast skill at lead times of 3-4 weeks – this provides new, long-lead precipitation forecast information for Calif.

NASA/JPL has teamed with the global weather & climate forecast communities to <u>enable and improve MJO forecasts.</u>

<u>Next Steps: Research to Operation activities with DWR.</u>